Appendix G. Special Project to Enhance Coho Salmon Productivity by Utilizing Habitats Upstream of Anadromous Barriers

CONTENTS

G.1 PROJECT OVERVIEW

Green Diamond will undertake a special project that it anticipates will “jump start” the conservation of coho salmon by increasing the available habitat for spawning and rearing. Green Diamond will undertake one project to trap and transport adult coho salmon that are native to the respective stream system downstream of a barrier to anadromy. These spawners would then be allowed to spawn naturally in the previously unutilized habitats upstream of the barrier to anadromy. This project would be conducted and monitored over a ten-year period.

Small numbers (approximately 10 male/female pairs) of adult coho spawners would be carefully captured at weirs. These selected adults would then be anesthetized using MS-222 or CO_2, tagged (e.g. floytags), and gently placed into restraining and transport tubes made of PVC pipe. The selected fish then would be placed into large holding tanks on a flatbed truck. These holding tanks will be fitted with aeration or an oxygen supply to ensure adequate dissolved oxygen concentrations during transport. The water in the holding tanks should contain a therapeutic dose of 3% NaCl and/or an artificial slime agent such as PolyAqua® to reduce handling stress and loss of natural mucous. The selected adult coho salmon would then be transported to a release point upstream of the anadromous barrier and set free in a pool habitat following their recovery from capture. Several capture events and transport trips would be likely required to transport all the coho spawners selected for relocation. Release of these spawners would occur at a location upstream of the anadromous barrier that insures that the translocated spawners are not swept downstream over the barrier following their release.

The selected coho spawners will be monitored following their release to document any spawning success. If spawning is observed, subsequent surveys will be conducted during summer months to assess spawning success and the utilization of summer rearing habitats in the reaches upstream of the anadromous barrier by the juvenile fish. These summer surveys will also provide an opportunity to assess the potential interaction between the introduced coho population and any resident salmonids if present. Finally, out-migrant trapping will be conducted during the following winter/spring to document the number of coho smolts that emigrate from the system.

G.2 PROJECT GOALS AND OBJECTIVES

The goal of this project is to rapidly increase (within a few years) coho smolt production within the selected streams. This would occur concurrently but probably at a faster rate than the anticipated improved stream habitat conditions with the Plan Area. As analyzed below, although the capture of coho for movement around impassible barriers may technically constitute “take” of individuals, the project is not expected to cause unacceptable impacts to any Covered Species. An objective of the project would be to assist coho populations to fully maximize available spawning and rearing habitats within the selected streams or watershed.

G.3 PRE-PROJECT EVALUATION

Prior to selecting a stream to conduct the project, the stream will undergo a pre-project evaluation for its suitability. The project area will be evaluated in terms of the potential quality and quantity of coho habitat (i.e. spawning and summer and winter rearing). For the project to be effective, and meet the goal of rapidly increasing coho smolt production, many environmental conditions must be met. These include suitable water quality (temperature and clarity), adequate stream flows, velocities, and depths, appropriate spawning substrate quality (size) and quantity, sufficient food production, and a variety and complexity of cover for holding and refuge.

By carefully assessing the adequacy of a stream's habitats (quality) and its total spawning and rearing capacities (quantity), the worthiness of a stream will be determined. For example, if a projects' upstream location has high habitat quality but the quantity of habitat is small, in relation to the downstream area, it is likely that this location would not substantially increase overall smolt production. In that example, this stream would be ineffective in meeting the project goal (i.e. rapidly increase smolt production).

Secondarily, the stream will be evaluated in terms of its current use by resident salmonids and the potential for any negative impacts, especially to any of the other AHCP Covered Species. If there are existing conditions in the upstream areas of the project stream that likely would reduce the effectiveness of rapid smolt production (e.g. excessive predation on coho smolts), then this would negatively affect the overall effectiveness in meeting the project's goals. Such a stream location would not be selected for the project.

G.4 ANALYSIS OF PROJECT'S POTENTIAL IMPACTS

The following is a discussion of the potential impacts mechanisms and an examination of the likelihood of these occurring from the implementation of the project. It is likely that only a subset of any impact mechanisms would occur in a specific project location but for the purposes of this analysis, they will all be discussed.

G.4.1 Potential Impact Mechanisms

There are three principle groups of impact mechanisms, direct impacts, indirect impacts, and competitive (interactive) impacts. Many of these mechanisms overlap and will be discussed below.

The direct impacts to coho salmon that could occur from this project include:

- Death during transport and relocation of adults,
- Increased pre-spawning mortality,
- Increased egg mortality,
- Increased fry and juvenile mortality,
- Increased smolt mortality.

Indirect impacts to coho that could occur from this project include:

- Reduction in fry and juvenile growth rates,

- Delays in smolt emigration timing.

Competitive impacts that could occur include:

- Increased predation from resident species,
- Increased predation on other resident and anadromous aquatic species,
- Increased food competition with resident and other anadromous species,
- Displacement of one or more resident species or introduced coho salmon,
- Competition and predation on other anadromous species during out-migration.

G.4.2 Impact Analysis

G.4.2.1 Direct Impacts

The capture and transport of adult coho spawners has a large potential for direct losses (death) of the species and an increase in pre-spawning mortality following their release. Handling large fish can be awkward and potentially lethal to these fish if proper precautions are not taken. Fortunately, direct loss of adults during the capture, handling, transportation, and increased pre-spawning mortality following release can be minimized through planning and use of proven techniques.

If electrofishing is used as a collection method, attention to the power settings (i.e. 60 cps, D.C. pulsed power at low amperages and appropriate voltages) will eliminate adverse impacts to adult salmon during capture (K. Brown, FWS, pers. com). If capture is accomplished by use of picket weirs and traps, attention to construction (proper spacing of pickets and materials used), installation, and operations of the weir will eliminate losses and increased stress to adults during capture. Traps must be attended to frequently and trapped fish must be removed quickly and efficiently following their capture.

Handling techniques following adult capture including the judicial use of either MS-222 or carbon dioxide ($CaCO_2$) will result in safe anesthetization without risk or loss during handling. Risk of loss of adults during transportation also can be minimized and eliminated by use of techniques such as placement of captured fish into transportation "tubes". These tubes are lengths of large diameter PVC pipe with flapper doors on their ends and a carrying handle in which a fish is placed and lifted into a holding tank from an anesthetization tank. These tubes are effective in handling large adult salmon and eliminating stresses and losses (K. Brown, FWS, pers. com.). Following the placement of fish into transport tanks with aeration and appropriate therapeutics (to minimize risk of infection and disease) fish can be quickly transported to their release sites. Adults then can be placed into receiving waters to acclimate thereby further minimize any life threatening stresses and losses including increased rates of pre-spawning mortality. In summary, using these and other techniques, risks to adult coho spawners will be minimized and direct losses to adults can be minimized.

An increase in *in vivo* egg mortality could occur as a result of stress from capture, handling, transport, and release of coho spawners. However, as discussed above, risks are likely minimized and significant losses from these activities will be eliminated by the use of proper techniques during capture, handling, transport and release of adult spawners. Increased rates of *in vitro* egg losses resulting from the project are also unlikely. By adequately characterizing substrate composition, water quality, and water quantity, in the project location prior to selecting this location, any risk of increased rate of egg losses through spawning in unfavorable upstream habitats will be minimized, if not eliminated.

Increased rates of fry and juvenile mortality could potentially occur from rearing in upstream habitats as opposed to downstream habitat. This could occur from a number of mechanisms including unfavorable habitat conditions in the rearing areas or increased competition for food, and increased predation from resident species. Two physical factors play a large role in the survival of the freshwater life history of coho fry and juveniles, water discharge (volume) and water temperatures (Sandercock 1991). Extreme floods are often detrimental to the survival of coho fry and fingerlings (Sandercock (1991). Additionally, low summer flow conditions with a corresponding rapid rise in water temperatures from less than 20°C to >25° C can result in high coho mortalities (Brett 1952 as cited in Sandercock 1991). Prolonged exposure to 0° C can be tolerated by coho during winter month but water temperatures sharply dropping to near 0° C from 5° C may result in mortality to coho juveniles (op. cite.). While the likelihood of these conditions would occur in watersheds within the Plan Area is low, these conditions would be more likely to occur in upper watershed areas than in lower watershed areas.

An especially important environmental condition that will be carefully considered is quality and quantity of over wintering habitat. An important factor in coho fry production is the stability of winter flows (Lister and Walker 1966 as cited in Sandercock 1991). Furthermore, the availability of winter habitat is often overlooked as a limiting factor in juvenile coho production (Nickelson et al. 1992). These authors found that during summer months juvenile coho salmon preferred trench, scour, and plunge pool habitats over other pools or riffle habitats. During winter months the authors found that alcove pools ("sidepools") and beaver ponds which accounted for only 31% of the areas sampled, accounted for 66% of coho juveniles in surveys of coastal Oregon coho streams. Maximum pool depths for all pools types were highly correlated with juvenile coho density, but for alcove pools, pool depths were not an important correlate (op. cite.). Nickelson et al. (1992) concluded that it was likely for many Oregon coastal streams, coho salmon smolt production is probably limited by winter habitat availability. Larkin 1977 as cited in Sandercock 1991) states that coho abundance in a stream is limited by the number of suitable territories (rocks, LWD, and other structural elements within pool habitats). Careful consideration will be given to the volume of complex habitat available in the project stream including the availability and quality of coho winter habitat for fry and smolt production.

A discussion of the effects of competition and predation follows in the competitive impact section below. As discussed above, proper pre-project evaluation of habitat conditions, and careful consideration of incubation and rearing conditions will minimize risks for increased fry and juvenile mortality. Losses to rearing life stages can never be eliminated, but careful selection of an appropriate stream to conduct this project, will minimize the risk of incurring survival rates that would be lower than those for downstream habitat areas.

The potential risk of lower survival rates for smolts reared from upstream areas as compared to downstream areas are minimal but the rate of survival could be less for upstream reared smolts. This could occur because of greater travel distance to exit the stream (and corresponding increased rates of bird and fish predation) and possibly additional risks of injury and death during transit through the existing migration barriers. Factors that affect timing of smolt emigration include size of the fish, flow conditions, water temperature, dissolved oxygen, day length, and food availability (Shapovalov and Taft 1954, as cited in Sandercock 1991). There are no mitigation measures to avoid a risk to lower smolt survival during emigration other than through proper selection of the project location. Prior to selecting a project, the barrier to anadromy would need to be assessed as to its potential danger for successful smolt emigration. Prior to its selection, the upstream length of the project reach shall be evaluated as to its potential for stranding or injuring out-migrating smolts. If it were found a risk for successful smolt emigration (e.g., significant and deleterious loss during out-migration), this risk to the effectiveness of the project goal would be considered in the final selection of this stream for the project. However, due the nature of the coastal watersheds in the Plan Area (relatively short in total stream miles) it is unlikely that length of upstream reach would be a factor that would significantly affect smolt survival rates.

G.4.2.2 Indirect Impacts

Potential indirect adverse effects of the project could include reduction in fry and juvenile growth rates, and delays in smolt emigration. Fry and juvenile growth rates are primarily affected by water temperature and food availability. Given moderate water temperatures and abundant food supplies coho fry will grow from 30 mm at emergence to 100-130 mm by their second year (prior to emigration) (Roundsfell and Kelez 1949 as cited in Sandercock 1991). It is probable that in upstream stream reaches closer to the headwaters, a stream would have lower average water temperatures as compared to downstream reaches. With lower water temperatures a lower growth rate could occur for coho fry reared in upstream reaches. This however may be off set by greater food productivity in shallower, less turbid upstream stream reaches. In summary, it would be difficult to quantify the potential difference in growth rates of fry and juvenile coho without extensive data collection prior to the section of a project stream. An assessment of the temperature conditions and the food availability will be necessary prior to selecting the project stream and by doing so, the potential growth rates from upstream and downstream locations could be distinguished. It is unlikely that coho growth rates would significantly and adversely impact the effectiveness of the project.

Delays in smolt emigration may occur in upstream locations due to cooler water temperatures and slower growth rates (as discussed above). This could result in smaller overall size during peak out-migration months (March through May) as compared to smolts reared in downstream areas. Also, as previously discussed above delays in exiting the stream may occur with longer distances to travel from upstream rearing areas. However, it is unlikely that these factors would adversely impact the overall effectiveness of the project to rapidly increase the smolt production in the project stream.

G.4.2.3 Competition and Predation Interactions with Resident and Anadromous Species

Predation is a major source of mortality to juvenile coho salmon with the effects varying depending on the predator species present and the stream character (Sandercock

1991). In the Plan Area, cutthroat trout and steelhead/rainbow trout are the principle predators to juvenile coho. Sculpins are known to be important predators on coho fry from emergence (30mm) to approximately 45mm (Patten 1977 as cited in Sandercock 1991). In British Columbia, cutthroat trout were thought to be the principle predators of juvenile coho (Godfrey 1965 as cited in Sandercock 1991). However, in Oregon coho populations, Chapman (1965, as cited in Sandercock 1991) found that cutthroat trout were not significant in coho fry mortality as they were only occasionally taken by cutthroat trout even when coho fry were abundant. Coho fry and smolts are particularly vulnerable to predation when they are congregated in pools and side channels especially in years with high egg-to-fry survival rates (Sandercock 1991).

Predation in upstream project reaches could be a significant impediment to fry and smolt production if predator densities are high. Coho fry and juveniles may be a higher risk to predators in smaller habitat units that would typically be found in upstream reaches of a stream. However, if adequate refuge cover (LWD and SWD) is present in sufficient quantities, predation by trout and other species may be offset in these smaller habitat units as compared to larger less cover containing habitat units in larger downstream reaches. It will be necessary to determine the population densities of potential predator species in any areas in which coho may be introduced. Low densities of predator species such as cutthroat may not necessarily preclude successful and rapid fry and smolt production in project streams.

Coho fry feed principally on insect drift preferring to occupy slower moving sections of smaller streams (Sandercock 1991). Mason (1971, as cited in Sandercock 1991) found that 80% of food contents of coho stomachs was winged dipterans (true flies). Yearling coho may become predatory on fry of their own kind or of other species (Sandercock 1991). However, Shapovalov and Taft (1954, as cited in Sandercock 1991) found that in California coho and steelhead fry were not preyed upon because they emerged from the gravel after coho smolts had emigrated to sea. However, those authors did report that large numbers of chinook fry were preyed upon by coho smolts. Coho smolts would be expected to begin out-migration in March or April ending in June in most years (see Appendix C). Therefore, due their out-migration timing, it is unlikely that coho smolts in upstream reaches, to which their parents were introduced, would prey, to any significant level, on resident trout, steelhead, or coho young-of-the-year.

In these circumstances, it would also be unlikely that chinook fry would be present to be preyed upon by coho yearlings/smolts. Adult chinook are much less athletic than anadromous steelhead and cutthroat trout and therefore would not likely reach habitats upstream of the barrier to anadromy to spawn. Chinook fry that are rearing in downstream reaches however, may be preyed upon during active coho smolt emigration. However, if chinook or other salmonid fry production were sufficiently robust in the downstream reaches, the impacts of predation from out-migrant coho smolts would not likely be significantly large and have little adverse impact to those populations. If populations of these species were not sufficiently robust, then predation from out-migrating coho smolts may be deleterious.

Predation of tailed frog tadpoles by yearling coho produced from introduced adult coho would unlikely occur to any great extent. Rearing tailed frog tadpoles have been shown to prefer higher gradient riffles and faster flowing habitats (Diller, unpubl. report). Tailed frog eggs are deposited in the summer and hatch after four to six weeks (Brown 1990). In coastal regions, the tadpoles typically do not emerge from the nest site until later in the fall (Diller unpubl. report). In contrast, feeding activity of coho fry (which are not predatory on fish or non-insects) decreases in late summer. Young-of-the-year coho move into deeper pool habitats of a stream in the late summer and early fall months remaining in those habitats throughout the winter (Hartman 1965; Scott and Crossman 1973; and Bustard and Narver 1975 as cited in Sandercock 1991). Following winter, yearling coho may prey on tailed frog tadpoles to some extent if they are encountered but the period of predation would be rather short before the coho smolts emigrate out of the rearing stream beginning in March or April.

In summary, the likelihood that coho juveniles produced from introduced spawners would be significant and adversely impact other salmonid juveniles or tailed frogs is small. Predation of these species by yearling coho would be minimal and likely have little impact on those species' populations unless coho were to fully fill the available rearing areas within the stream reaches in which introduction occurred. Even in that event, structurally complex habitats (complexes of LWD, SWD, boulders, cobble, undercut banks and submerged vegetation) within these reaches would likely provide sufficient refuge for steelhead and trout fry and tailed frog tadpoles. Green Diamond will carefully consider existing populations of resident and anadromous species before selecting a stream for introduction will minimize negative impacts of coho predation on those species.

The potential for predation from avian and mammal (i.e. mink, otter, and fishers) species must be considered when selecting the project stream. Upstream areas without sufficient cover, either vegetative, or visual cover such as bubble curtains, would provide greater opportunities for predation by these species. Avian and mammal predation rates on coho may be lower in downstream reaches where fry and smolts may be dispersed over larger areas (lower densities) than that in upstream areas.

Coho fry demonstrate territorial behavior and once selected remain in a locality for relatively long periods (Hoar 1958 as cited in Sandercock 1991). Displacement from their preferred territory may come from a cohort or a competitor fish species. Conversely sufficiently large numbers of juvenile coho may displace other juvenile resident or anadromous species if habitat quality and quantity is inadequate. If sufficient habitat structural complexity is available and the competitor or coho cohort density is sufficient low the individual coho fry will remain in its chosen territory or it may choose to relocate. If excessive disturbance, harassment or displacement from its chosen territory occurs, coho will relocate and avoid the competitor. If displacement continues with no ability to rest on the stream bottom, juvenile coho will progressively be displaced downstream (Chapman 1962 as cited in Sandercock 1991). It that case displaced coho juveniles may, given sufficient numbers and habitat limitation, displace other resident and or anadromous juveniles in those downstream reaches. The essential parameters here are availability and abundance of structurally complex habitat and the density of competitors. Similar to predation, the effects of competition on coho fry and smolt productivity, is minimized if sufficient cover and territory is available and competitor density is not excessive; thus, the existence of sufficient cover and territory, as a ratio of competitor density, will be a project site selection criterion.

G.4.3 Conclusions

The most significant measure to ensure that the project will be effective in meeting its goal is the careful consideration in selecting a project location. Attention will be given to the necessary habitat conditions, the density and the species of potential competitor and predator species, and the limiting factor(s) to coho fry and smolt production in both the upstream and downstream areas being considered for introduction. These elements will be carefully weighed together and compared to the potential productivity that would occur in areas within the project area if coho introduction were not attempted. Green Diamond will only select a project stream location that meets all of the criteria necessary discussed herein. Accordingly, no unacceptable adverse impacts to coho salmon or other Covered Species in the Plan Area are expected to occur.

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